Document A

PHYSICAL WATER CONDITIONERS TEST

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INTRODUCTION

Physical water conditioners are devices intended to prevent the build-up of hard limescale in a physical (i.e. non-chemical manner) manner. This is done by influencing the ions in the water so that when the saturation point of the water is altered (e.g. by heating) the calcium carbonate (or other minerals) precipitates as small crystals in suspension in the water, rather than as a solid mass bonded to surfaces.

This contrasts with treatment methods where the chemistry of the water is altered.

CHEMICAL TREATMENTS

Chemical treatments are not the focus of the present discussion. Nevertheless, they are briefly described here for completeness and for contrast.

- Water softener
    - Replaces the calcium and magnesium ions in the water with sodium ions.
- Reverse osmosis
    - Passes water through a semi-permeable membrane, so that all ions are removed
- pH control
    - Adjusts chemistry of the water to prevent scale formation

TYPES OF PHYSICAL TREATMENT

- Intrusive magnets
- Clamp on magnets
- Intrusive Electromagnets
- Non-intrusive Electromagnets
- Electrolytic
- Signal wire Electromagnets
- Open-ended double Signal wire
- *Hydro*FLOW

INTRUSIVE MAGNETS

These were the first physical water conditioners that appeared after the discovery that water flowing over magnetic rock did not scale.

Fig. 1 illustrates the general principles that are employed in the operation of intrusive magnets. The conductors represent the water that is moving and cutting the magnetic lines thus generating a voltage represented by the + and - on the ends of the conductors. The Voltage that can be generated by utilising such an arrangement depends on the strength of the magnet and the speed of flow of the water.

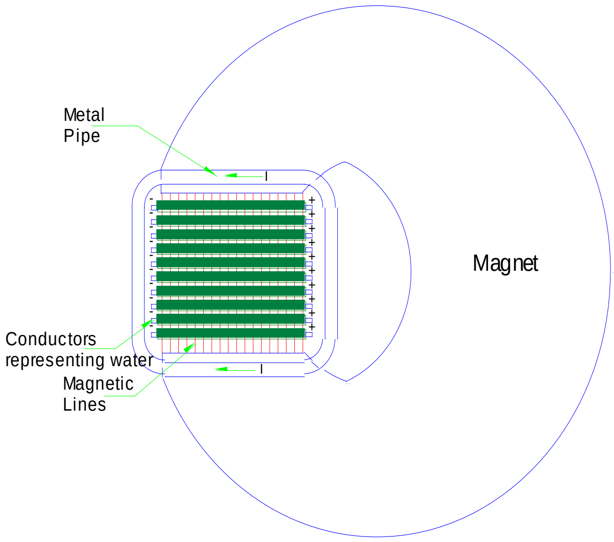

Figure 1: Intrusive Magnet

I represents the current that is generated as a result of the voltage. The current will be dependent on the voltage and the conductivity of the water. The current that is produced by this method is DC (Direct Current). It will act as a galvanic current causing corrosion and will release metal ions into the water.

Any clusters that are formed due to the electrical field near the magnets will be carried by the water flow towards the source of heat. Some clusters will grow by attracting more ions and some will dissolve back. These clusters are not stable and will break up to individual ions after a relatively short time (3.5min). If enough clusters can reach the source of heat they will grow to form nuclei and the crystallisation will occur as described above.

This dependence on the rate of flow and conductivity of the water explains the unreliable results that are being achieved by utilising this method. In addition, a permanent magnet will attract magnetic particles flowing in the water causing reduced efficiency and increasing the possibility of complete occlusion of the pipe. No enhanced nucleation can occur beyond the magnet itself, as the effect is localised to the magnet.

When used on plastic pipes, magnets have no effect because the electric field cannot be formed without the metal path for the current to flow. In industrial circulating systems a small degree of success can be achieved.

CLAMP-ON MAGNETS

These are constructed mainly of ceramic magnets that are plastic coated. Two individual magnets are clamped on the pipe to create the magnetic lines. These are attenuated by the large air gap between the magnets. There is no way to control the speed of flow of the water and there is no reliable scientific evidence to prove that benefits claimed are being produced.

It is debatable if such an arrangement can generate an electric field capable of forming clusters. Manufacturers producing such devices claim that results can be achieved with any pipe material, however it is clear from the above that this cannot be the case.

ELECTROMAGNETS

With correct design it is possible to generate strong magnetic fields with Electromagnets. It is also possible to control the speed of flow by restricting the flow. These devices suffer the same disadvantages as the permanent intrusive magnets described above. An additional disadvantage is that they must be connected to an electrical source, resulting in installation and running costs. The only advantage of Electromagnets over permanent magnets is the ability to be switched off thereby releasing any magnetic particles that may have accumulated in it.

NON-INTRUSIVE ELECTROMAGNETS

These are categorised by signal cables that are wrapped around water pipes in an attempt to generate a magnetic field. These may vary from 50 Hz coils carrying mains voltage to a single wire coiled on the pipe. The signal used in the latter is mainly a square wave at an ultrasonic frequency.

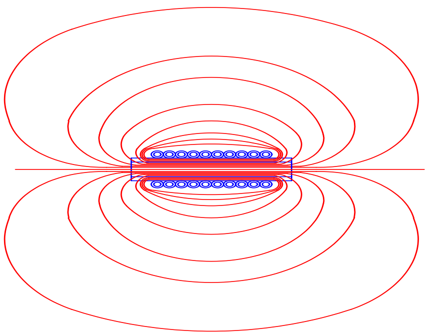

Figure 2: Magnetic field lines produced by a non-intrusive electromagnet

Fig. 2 illustrates a section of pipe and the coil wound around it. The red lines represent the magnetic field lines. As can be seen, most of the magnetic lines run parallel to the moving liquid, thus in theory no electrical field can be generated within the electromagnet.

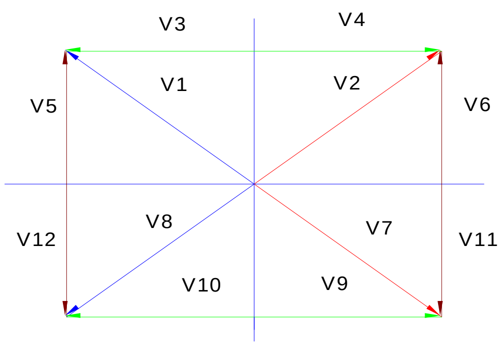

Figure 3: Vector summation of the magnetic field lines produced by an electromagnet.

Some of the magnetic lines beyond the ends of the coil flow between the poles and will cut the liquid at shallow angles. This will generate weak electric fields at both ends of the coil. The fields will be generated at right angle to the magnetic lines. Fig.3 represents the voltages that are generated in the water. Since each magnetic line has its equal and opposite line in the same axis, the voltages that are generated (V1 and V2, V7 and V8) are complimentary. These form V3 and V4, V5 and V12, V9 and V10, V6 and V11 that are equal and opposite. Thus the overall voltage should be 0. In practice due to uneven distribution of the magnetic lines, the voltages do not cancel completely. (This will be shown later in an experiment specifically designed to measure such voltages.)

There are other reasons for variation in the electric field that may be formed by this method. The main one is the turbulence of the water flow within the pipe. The water flow within a pipe may not flow linearly. This depends on many factors, and will be completely different between one installation and another. The turbulent flow within the axial magnetic lines will cause uneven voltages within the electromagnet. These variable conditions can explain the reason that in some cases these devices have some success and in others they fail completely.

ELECTROLYTIC

Electrolytic conditioners are basically a battery. These conditioners operate on the well-known principle that if metal electrodes, made from different materials e.g. zinc and copper, are immersed in an electrolyte; between them. Zinc ions are then released into the electrolyte (water) by the anode. The release of positive zinc ions into the water will release electrons that will flow to the copper cathode through the connecting wire. This process will continue until the zinc anode is completely dissolved.

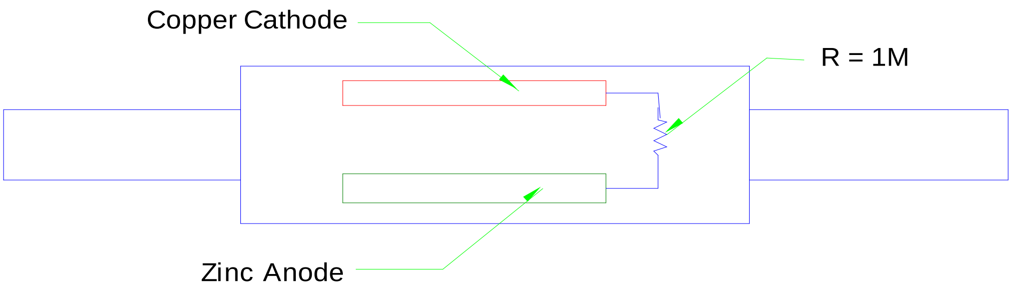

Figure 4: Electrolytic Conditioner

Fig. 4 illustrates the basic construction of an electrolytic conditioner. The electrodes are connected by a large resistor 1M (1, 000, 000 Ohms). This is done to increase the life of the zinc anode, but will drastically reduce the electrical field applied to the water. The manufacturer is faced with the problems of increased conditioning effect at the expense of the life of the conditioner. A balance has to be achieved. A reasonable life span is only obtained with the conditioning effect reduced.
It is generally accepted that these conditions are producing an effect. And, as there is solely an electrical field being generated (no magnetic field) to obtain scale inhibiting, this is one more proof that it is the electrical field that is responsible for the conditioning effect as described above.
There are numerous disadvantages with such conditioners.

- The life of the conditioner cannot be determined. It is affected by the conductivity of the water that varies considerably from area to area.
- As the anode is exhausted the conditioning effect will stop. Damage to expensive appliances may result.
- Zinc ions are released into the drinking water.
- Regular and expensive maintenance has to be performed to ensure reliable results.
- The conditioning effect can only be transported by the flow of water

SIGNAL WIRE COILS

There are numerous manufacturers of the signal wire electromagnet. All are based on two basic designs. 1) One coil is wrapped around the pipe and is connected to the signal generator. 2) Two coils are wrapped around the pipe, one end of each coil is connected to the signal generator, and the other end is left open. Dutch and Belgian inventors have patented both designs respectively (However, many copies of these desgins have been in production for the past 20 years without any apparent difficulty).

In general they produce the same swept frequency square wave signal of 1 KHz to 6 KHz. Various designs have appeared in the amateur electronic press.

For example in Elektor Electronics international electronic magazine issue July August 1994, an article headed "Water Softener", describes in detail the construction of such circuitry with single, double and triple coil systems. The article contains claims of discovery of unnamed researchers. Numerous manufacturers that started in business since that time have repeated similar claims.

In addition to *Hydro*FLOW the other designs chosen for this experiment, are the two most actively advertised in the UK. There is a simple way to test the signals produced by such devices. This test can also be applied to the *Hydro*FLOW electro physical conditioner.

EXPERIMENTAL METHOD

Figs. 5, 7 illustrate the way the test equipment is connected to the conditioners. The objective is to measure the level of signal that may be induced.

Conclusions can then be drawn as to the ability of the different technologies to induce a signal into the water thereby affecting the rate of scaling.

There are only two ways to apply an electric field to the water. The first is to directly connect a voltage source to the water by contact. If a voltage is present on a pipe this will be transferred to the water by contact. The second is to induce a voltage directly to the water by utilizing a magnetic field. This experiment is designed to test the second method.

It is desirable to have 2 or 3 oscilloscopes or a double beam oscilloscope to measure the voltages simultaneously. The experiment may be run using a single oscilloscope, by taking note of the reading at the various points as indicated in fig. 5.

The coils are wound on to a short length of copper pipe filled with water.

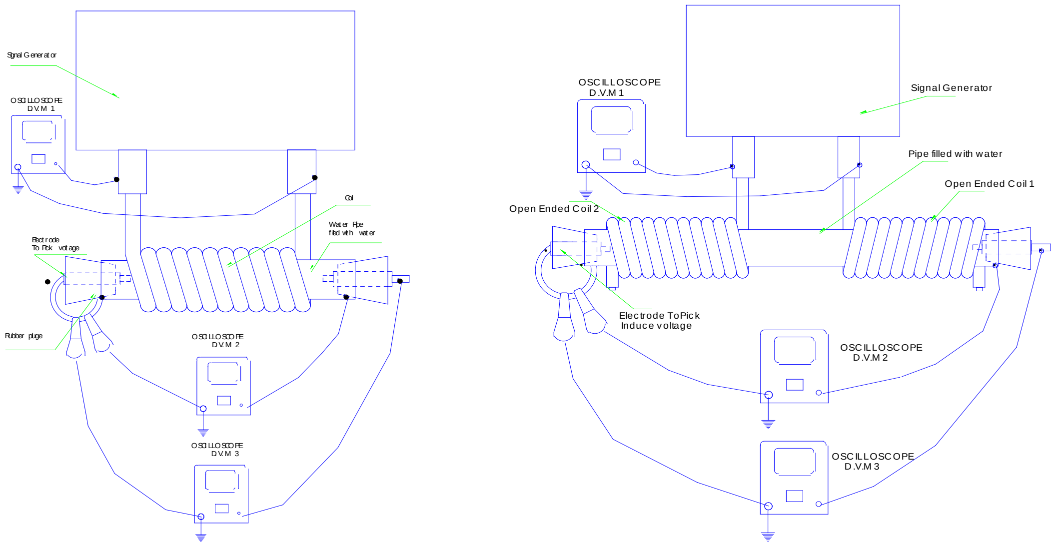

Figure 5: Testing on the single and double coil systems

SINGLE COIL SYSTEM

Connect the single coil water conditioner as illustrated in Fig. 5. Set the VOLT/DIV of the oscilloscope (scope) to 2V. Set the SWIP TIME/DIV to 0.1 ms. The inductance of the coil is very low. To be able to view the output signal it is necessary to disconnect one end of the coil from the signal generator. Connect the scope directly to the output terminals of the signal generator. A signal as illustrated in Fig. 6a will be observed on the scope. The voltage will be 4V peak to peak (p to p) and the frequency may be between 5-6 kHz. This is the top frequency. Connect the coil back to the signal generator. To be able to observe the signal, change the VOLT/DIV of the scope to 5 mV (0.005 V). If the probe is set to X10, reduce it to X1. A signal as illustrated in Fig. 6b will be observed. The voltage will be 15 mV p to p. The frequency will be swept between. 240 Hz and 6 kHz. The drastic reduction in output is due to the large load that the small inductance is exerting on the signal generator. Reduce the VLT/DIV to 1mv and connect the probe on the pipe as illustrated in Fig.5, then observe signal is as Fig 6c. This 1 mv p to p is noise that is generated due to mains pick-up on the scope.

Connect the probe of the scope to the wire in the middle of the pipe as illustrated in Fig. 5. With careful setting of the TRIGGER LEVEL of the scope it will be possible to observe a signal similar to Fig. 6b at the voltage of 1mv p to p. This is the highest level of signal pulses that such a system is able to induce in the water. The energy that is produced by any oscillating electrical signal is the R.M.S. value or the equivalent D.C voltage that will produce the same energy. For example: The p-to-p value of a sin wave AC voltage equivalent to a 1.5 VDC battery will be 4.2 VAC. The value of the p-to-p mains voltage in the UK is 678 VAC but the Mains voltage is quoted as 240 VAC. It is the energy of the electrical field that is responsible for the orientation of the ions in the solution. The R.M.S. value of the of the sharp spike as illustrated in Fig. 6b is tiny in proportion to the p-to-p value.

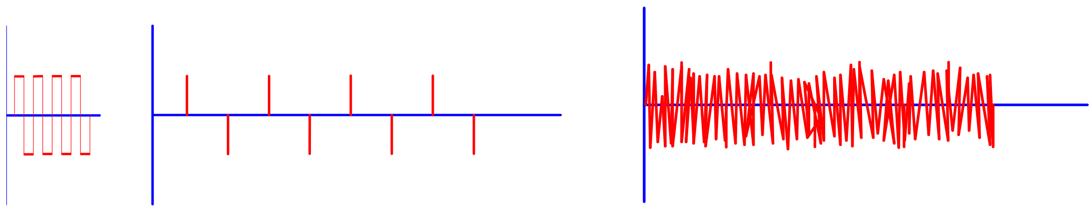

Figure 6: a) a square wave b) individual short peaks (the derivative of the square wave) and c) noise from the mains signal

DOUBLE COIL SYSTEM

Connect the double coil as illustrated in Fig. 5. Set the VOLT/DIV to 5 V. Adjust the TRIGGER LEVEL to obtain the signal as illustrated in Fig. 6a. The Voltage on scope 1 will be between 12 to 30V p-to-p square waves as illustrated in Fig. 6a. The signal on scope 2 and 3 will be the same 200 mV p-to-p pulses as illustrated in Fig 6b. The test with the wire inside the pipe as illustrated in Fig 7 can be performed. The same results will be achieved.

As can be seen, the level of energy that can be induced with such system is very limited indeed.

HYDROFLOW

With ***Hydro*FLOW** two tests are performed - one with the pipe filled with water and the other with a wire fitted in the middle of the pipe.

The first test repeats the test on the signal wire devices above.

Repeat the above test with the connections as illustrated in Fig. 7a. The resulting waveform and voltages will be exactly the same. This is because the water in the pipe acts as a conductor that experiences the same induced voltage. Set the VOLT/DIV to 1V. Adjust the TRIGGER LEVEL to obtain the signal as illustrated in Fig. 8. With ***Hydro*FLOW** HS38 the voltage will be typically 8V p to p. The voltage measured in the water will be exactly the same.

For the second test, the ***Hydro*FLOW** is installed in the middle of the copper pipe. The pipe is fitted at each end with convenient points to attach the oscilloscope. A length of insulated wire, slightly longer then the pipe is inserted in the pipe. This is to demonstrate the induced voltage in the water, and specifically, that the copper pipe does not "shield" the wire from the applied signal.

Connect ***Hydro*FLOW** as illustrated in Fig. 7 set the VOLT/DIV to 1V. Adjust the TRIGGER LEVEL to obtain the signal as illustrated in Fig. 8. With ***Hydro*FLOW** HS38 the voltage will be typically 8V p to p

Exactly the same voltages will be measured on the wire in the middle of the pipe. There is no connection between the pipe and the insulated wire inside it. The voltages measured are exactly the same. This is due to the oscillating coaxial magnetic field that is generated by ***Hydro*FLOW.**

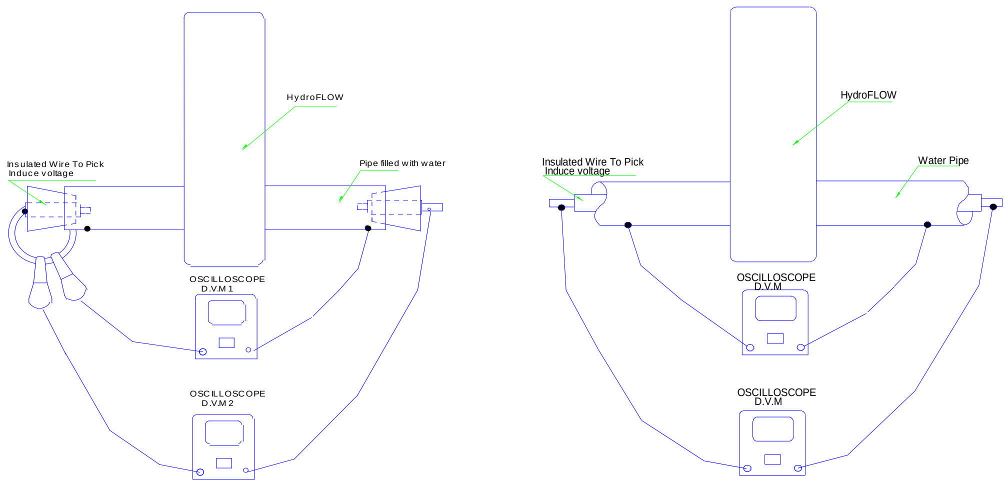

Figure 7: Testing on the Hydroflow

The ***Hydro*****FLOW** conditioner is a sophisticated signal generator. International P.C.T. patents protect it. It is able to produce a complex waveform. This waveform is fed to a ferrite core. In the domestic range to facilitate installation, the core is divided into two sections that are pressed together by a leaf spring. In the commercial and industrial units the core is constructed in segments. It is within this core that the oscillating coaxial magnetic field (O.C.M.F) is generated. The O.C.M.F. induces a voltage in the pipe, and in the water in the pipe. These two voltages are exactly the same, as can be seen in the test. Since there is no voltage difference between liquid and metal, no current can flow between them. This will eliminate any corrosion that would have otherwise formed. The frequency of oscillation may be between 100 - 160 KHz.

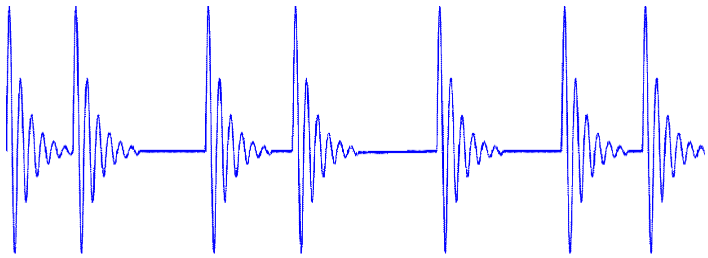

Figure 8: The hydropath signal

POWER TO WATER RATIO

Product	Power Transfer Ratio
Single Coil	0.0000015
Double Coil	0.000039
HydroFlOW	1

These tests clearly demonstrated the advantages of the HydroFLOW technology over the other generic types. The implication of these tests are that all other generic types of water conditioners acts on the water only at the installation point (The installation instruction clearly demonstrate this) and are flow dependent. It is necessary for the water to flow within the unit to transfer energy to the water. The flow has to be slow enough to transfer the energy to the water. If it is too fast not enough energy will be transferred to create the effect, if the flow is too slow it will take too long to reach the area where the water is precipitating and the effect will decay away (about 3.5 min). This is the reason that manufacturers specify flow rates and maximum flow, necessary for proper operation of such devises. Such flow-rates are unlikely to be achieved in practical applications.

To prevent scaling, energy has to be transferred to the water to change the crystallisation from the surface to suspension. This is what happens with all the physical water conditioners on the market. Since we published this explanation of the process, all manufacturers of physical water conditioners had adopted it.

Hydro**FLOW** technology works differently by applying the energy efficiently to all the plumbing system, this by propagating the electric field throughout the plumbing system, thus creating clusters of ions everywhere and recreating the clusters that have been dissolved back into solution by the water (HydroFLOW installation instruction clearly demonstrates this).

CRYSTALISATION

The physical effect that the Hydroflow has can be seen in the differences in the shape of the crystals formed be treated and untreated water. This test was doen in a laboratory by heateing and evaporating treated and untreated water. Note that in a nomal application rather than a laboratory test, the untreated water would form scale on surfaces rather than the free-floating crystals seen here.

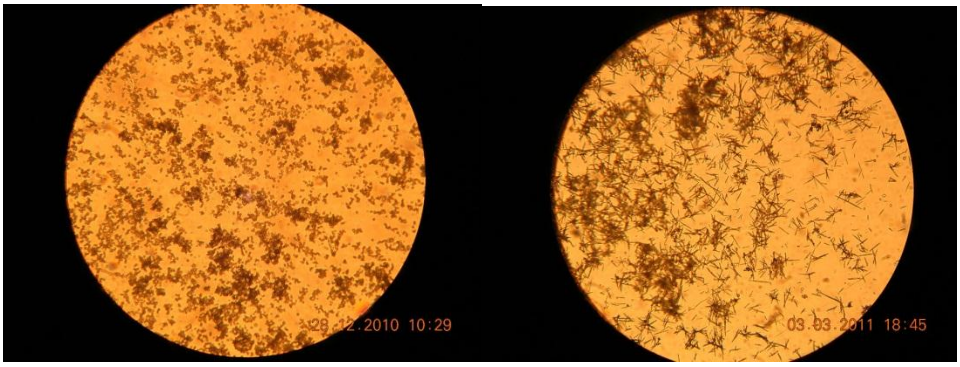

Figure 9: Crystals formed by untreated water (left) and treated water (right)

Crystals formed by water treated with Hydroflow (in this test) tend to be longer, thinner and more fragile.

This clearly indicates the physical difference in the crystals created.